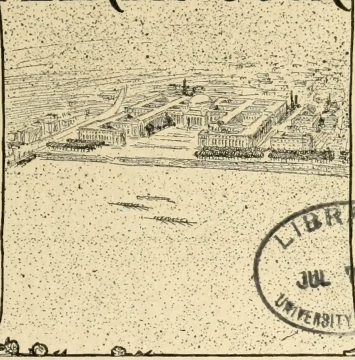
Applied Sci.
Serials

The TECHNOLOGY MONTHLY ENGINEERING JOURNAL



LIBRARY
JUL 7 1922
UNIVERSITY

Dec. 1916 Vol. III, No. 5

The Massachusetts Institute of Technology

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY aims to give thorough instruction in *Civil, Mechanical, Chemical, Mining, Electrical,* and *Sanitary Engineering;* in *Chemistry, Electrochemistry, Architecture, Physics, Biology* and *Public Health, Geology, Naval Architecture;* and in *Engineering Administration.*

To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in algebra, plane and solid geometry, physics, history of the United States (or Ancient History), English, French and German. Preparation in two of a series of elective subjects is also required. A division of these examinations between different examination periods is allowed. In general, a faithful student who has passed creditably through a good high school, having two years' study of French and German, should be able to pass the Institute examinations.

Graduates of colleges, and in general applicants presenting certificates representing at least a year of satisfactory work at another college, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end extensive laboratories of chemistry, physics, biology, mining, mechanical engineering, applied mechanics, and the mechanic arts, have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. So far as is practicable, instruction is given personally to small sections rather than by lectures to large bodies of students.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degrees of Master of Science, Doctor of Philosophy, and Doctor of Engineering are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories, in the three recently established Research Laboratories of Applied Chemistry and Physical Chemistry, and in the Sanitary Research Laboratory and Sewage Experiment Station.

The tuition fee, not including breakage in the laboratories, is $250 a year. In addition, $30 to $35 per year is required for books and drawing materials.

For catalogues and information, address

Professor ALLYNE L. MERRILL, *Secretary of the Faculty,*
Massachusetts Institute of Technology
Cambridge, Mass.

PREPARE FOR THE INSTITUTE

At CHAUNCY HALL SCHOOL 553 Boylston Street, Copley Square

The only school confining itself wholly to preparing men for the Institute of Technology

ADVANTAGES:

New quarters, newly furnished, near the Institute.
Chemical and Physical Laboratories equipped with the best of apparatus.
Teachers who are specialists in their several departments.
The number of students in classes is limited, that all may get the most thorough instruction.
Our candidates not only pass their entrance examinations, but maintain high standing at the Institute

Tech men are invited to inspect the school, or to write for particulars. FRANKLIN T. KURT, Principal

Bausch & Lomb

Engineering Instruments

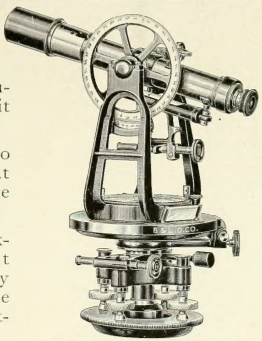
Consider the purchase of an instrument as an investment--you buy it for many years' service.

You would want an investment to give a certain return--you know what your requirements are for the service from a transit or a level.

Behind your bond there must be excellent security--an instrument would be no good to you if it merely served today and tomorrow broke down, and failing to hold its adjustments gave inaccurate readings.

Write for Metro Manual--our new handbook of unusual value to the engineer.

Compare with other instruments--then buy



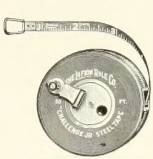
4½-inch Tachymeter—Special interior focus; Waterproof construction; Tarnish-proof graduations, etc.

Bausch & Lomb Optical Co.

NEW YORK WASHINGTON CHICAGO SAN FRANCISCO
LONDON ROCHESTER, N.Y. FRANKFORT

LUFKIN Measuring Tapes

"Measure up" to to-day's exacting standard of engineering work and stand approved by the good judgment of the engineering world



THE LUFKIN RULE CO.

SAGINAW, MICH., U. S. A.

LONDON, ENGLAND
106 Lafayette St.

WINDSOR, CAN.
NEW YORK

"We are advertised by our loving friends"

A Typical
Mellin's Food
Boy

Edward A. Watkins
San Diego, Cal.

The Technology Monthly
Engineering Journal

A MAGAZINE DEVOTED TO THE INTERESTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Vol. III | Contents, December, 1916 | No. 5

HANOVER STREET BRIDGE, BALTIMORE, MD.		4
THE ELECTRICAL ENGINEERING LABORATORIES OF THE INSTITUTE	F. A. Laws, C. W. Green, C. L. Dawes	5
HANOVER STREET BRIDGE	Edward Cameron	12
"BLACKIE"	Robert E. Rogers	16
HISTORY, DEVELOPMENT AND EXTENSION OF THE ELECTROMAGNETIC SPECTRUM. II	H. P. Hollnagel	18
FACTORY LIGHTING	Frederick N. Price	23
FIELD DAY	A. E. Tuttle	27
HEAT TREATMENT OF WROUGHT IRON CHAIN CABLE		29
EDITORIAL		30
Beardless Chins		
Percival Lowell, Harvard '79		
Get Behind the Band Wagon		
CARTOONS	L. F. Van Zelm, and "Hank"	
Doings About the Institute		37
About the New Tech Dorms		38
Not a Chance		42

Copyright, 1916, by The Technology Monthly

Entered as second-class matter at the post office, at Boston, Mass. Published monthly during the college year by the students of the Massachusetts Institute of Technology. Publication office, Massachusetts Institute of Technology, Cambridge, Mass.

Mail Address: Technology Monthly, M. I. T., Cambridge, Mass.

Subscription rate, $1.50 per year; 25c. per copy. Advertising rates upon application

HANOVER STREET BRIDGE, BALTIMORE, MARYLAND—*See page 12*

THE TECHNOLOGY MONTHLY
ENGINEERING JOURNAL

VOL. III CAMBRIDGE, MASS., DECEMBER, 1916 NO. 5

THE ELECTRIC ENGINEERING LABORATORIES OF THE INSTITUTE

By F. A. LAWS, C. W. GREEN, AND C. L. DAWES

Editor's Note. In the remaining issues of the year we plan to cover several of the different new laboratories of the New Institute. All of Technology's laboratories are equipped in the best possible manner and with all of the new appliances and years of experience back of them. One of the largest is the combined laboratories of the Electrical Engineering Department which is treated in the following article.

THE courses at the Institute have always been characterized by a liberal use of the laboratory method of instruction. The work of the classroom is thus reinforced and training given in those habits of accurate observation and the orderly arrangement of the results of observations which are so essential in engineering work.

From the time of the establishment of the course in Electrical Engineering, it has been the constant aim of its Instructing Staff that the laboratories should be the best that could be provided for teaching purposes, and in order that the Institute might maintain its primacy in this important element of engineering education, a special committee from the department made a careful study of the laboratory requirements at the Institute and also of the arrangements of other laboratories before deciding upon the general layout and the equipment of the new Electrical Engineering Laboratories.

In planning these laboratories, certain essential points were kept in mind.

(1) Power must be supplied in such forms that consistent results are easily obtained in the experimental work This means that the direct current supply must have a constant voltage, and that both the voltage and the frequency of the alternating current supply be substantially constant. In addition, the voltage waves of the various generators supplying the laboratories should be nearly sinusoidal and the voltages on the polyphase circuits should be balanced.

(2) A wide range of voltages, currents, and frequencies must be provided, for it is necessary to be able to test the various materials used in Electrical Engineering, as well as practically all sorts of commercial apparatus such as motors, generators and meters.

(3) Means for quickly and conveniently making connections and obtaining power must be provided. At the same time the number of leads and temporary connections running across the floors must be reduced to a minimum. It is therefore necessary to provide a large number of power outlets well distributed about the laboratories.

(4) All individual outlets must be adequately protected so that short cir-

cuits will not interrupt the supply to the rest of the laboratory and thus hamper the work of the classes.

All the power used at the Institute is generated at the Power Plant on Vassar Street at the northern extremity of the site, and transmitted through a tunnel 600 feet long to the Distributing Station in the basement of Building 10. The general scheme of the power distribution is shown diagrammatically in Fig. 1. In the above machines, there is a turbine driven, 150 kw., 230-volt direct current generator which feeds into the 230-volt direct current station bus. This 230-volt bus is also fed by two 150 kw., 230-volt generators, each of which is driven by a 225 h.p. 2300-volt induction motor. These induction motors are supplied directly from the 2300-volt, 3-phase bus, as shown in Fig. 1. Therefore alternating current power at 2300-volt, 3-phase, 60-cycles and direct current power at 230 volts (with 115 volts to neutral) are available at the power plant.

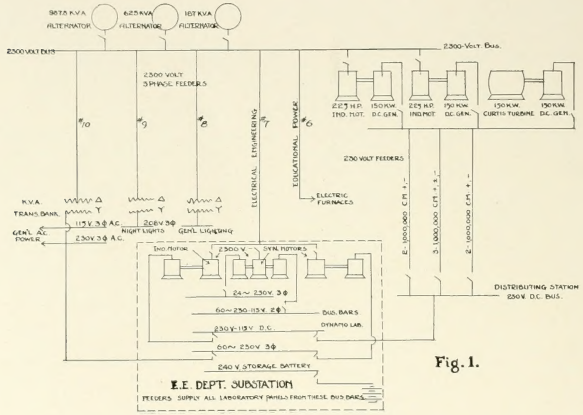


Fig. 1

In the power plant there are three turbo-alternators, having capacities of 937.5, 625, and 187 k. v. a. respectively. These machines, which supply the bulk of the power, feed into 2300-volt, 3-phase, 60-cycle bus bars. The number of generators in service at any one time is of course determined by the demand upon the power plant. In addition to this figure no attempt is made to show auxiliaries and details such as exciters, auxiliary bus, etc.

Feeders from the 2300 volt bus-bars and the 230-volt bus-bars run to the distributing station in the basement of Building 10, which is directly under the dome. These feeders are shown in Fig. 1. Feeder No. 10 runs to a k. v. a. Δ—Y transformer bank where the current is transformed to 230 volts and

to 115 bolts, 3-phase, for supplying the alternating current motors throughout the Institute. In addition, a line is run from this same supply to the switchboard in the Electrical Engineering Department Substation. Provision is made for connecting laboratory circuits to this alternating current supply when occasion demands.

Feeder No. 9 and Feeder No. 8 both run to transformer banks and the potential is stepped down to 208 volts, 3-phase with neutral. Nearly all the Institute lighting is supplied by these two banks. Feeder No. 7 runs directly to the switchboard in the Electrical Engineering Department Substation. This board controls the motor generator sets, which ordinarily supply the power to all of the laboratories and research rooms in the department. Feeder No. 6 is intended primarily to furnish power for the electric furnaces in the Institute.

From the 230-volt direct current busbar in the power plant three main feeders run to the distributing station; these supply power to certain direct current motors and to the direct current motors used in the ventilating system. They also supply power to the Chemical and Physical Laboratories. A line runs from this same supply in the Distributing Station to the switchboard in the Electrical Engineering Department Substation, so that when necessary this 230-volt direct current power may be used for laboratory purposes.

The 230-volt alternating and direct current power received at the substation switchboard would be satisfactory for commercial power purposes. However, because of voltage fluctuations and phase unbalancing due to the other loads on these circuits, it would be unsatisfactory for experimental work. Hence the necessity for the departmental substation.

ELECTRICAL ENGINEERING DEPARTMENT SUBSTATION

The three motor generator sets, which supply the Electrical Engineering Laboratories with power, together with the switchboard controlling these sets, are located on the main floor of the Dynamo Laboratory.

One set of 250 kw. capacity consists of an induction motor, and a 230-volt, direct current, three wire generator; the second set, rated at 187 1–2 k. v. a., consists of a synchronous motor and a three-phase, 60-cycle generator. The third set, rated at 125 k. v. a., consists of a synchronous motor and two generators, one a 62 1–2 k. v. a. 24-cycle, three-phase machine, the other a 62 1–2 k. v. a. 60-cycle, three-phase machine. This latter machine supplies the single-phase and four-phase power to the laboratories through Scott transformers. By using this third motor generator set for single-phase power, the second set may be used exclusively for balanced three-phase loads. Separate exciters supply the field currents to each of the synchronous motors and the generators.

Remote control arrangements are used in the operation of all three motors on the motor-generator sets. The switches on the switchboard close relays back of the board which in turn energize the tripping solenoids on the 2300-volt oil switches. A green light on the switchboard adjacent to the remote control switch indicates that the oil switch is open, and a red light, that it is closed. In the case of failure of the remote control apparatus, the main oil switches can be operated by hand.

The induction motor which drives the direct current generator is started by first inserting a resistance in series with the rotor of the motor and then closing the line switch; this resistance

serves to decrease the starting current and is cut out as the set comes up to speed. Both of the synchronous motors are also started as induction motors, but the starting current is here reduced by first impressing a low voltage and then switching to a higher voltage and closing the direct current fields after the sets come up to speed.

The voltage of all four generators is automatically held constant by means of Tirrell regulators. The power supplied by these sets is thus at a constant voltage on the direct current set, and on one-phase of each of the alternating current sets. Since only balanced power is taken from the three-phase 60-cycle set, the voltages on this set will be balanced. The frequency of all the alternating current generators will vary with the frequency of the main power plant, the speed of the synchronous motors varying with the frequency of the supply.

In addition to the above machines, there is a 240–120 volt storage battery capable of giving 25 amperes for 8 hours. This battery is connected to all the laboratories and is available in special tests where great constancy of voltage is necessary.

DYNAMO LABORATORY

The Dynamo Laboratory, comprising a main floor and balcony, extends across the rear of Building 10. The main floor, occupying 8,000 sq. ft. of the basement of this building, is used for the heavier motors and generators,—that is, machines above 2 kw. in capacity. The balcony is reserved for the smaller dynamos and for transformers. A crane having a capacity of ten tons, spans the space inside of the balcony railing, and is used in moving machines about on the main floor and in transferring them from the main floor to the balcony.

Two feeders from each of the generators of the motor generator sets, supply the laboratory with power through fourteen large panels on the main floor, and four in the balcony. These panels are mounted on the eight concrete columns which extend up through the laboratory and support the dome. Two of the columns on the main floor have but one panel, the six remaining having two each. The direct current supply is protected by circuit breakers on these panels while the various alternating current feeders are protected by fuses.

Each feeder circuit is connected to bus-bars on these panels, to which are also attached the sockets for making the temporary connections to the laboratory tables. On each of these panels small incandescent lamps are mounted, which show red when the different circuits are alive. In the balcony, the four main panels are connected through switches to smaller distributing panels located at regular intervals along the inside and outside balcony walls. These smaller panels are fused and equipped with sockets from which temporary connections to the tables are made by the students, flexible leads being used.

On the main floor portable tables provided with circuit breakers, switches, ammeter short circuit blocks and flexible leads, are used for the measuring instruments necessary in any one test. Connections to the machine to be tested are made via the tables. In the balcony the motors are mounted on tables, space being left for the instruments. Outlets for water and waste water pipes are located at each of the tables along the inner railing of the balcony, making for convenience and neatness in the prony brake motor tests.

All the measuring instruments used in laboratory testing, such as ammeters, voltmeters, wattmeters, etc. are stored

in the Instrument Room, which opens into the Dynamo Laboratory on the main floor. A dumb-waiter connects this room with the balcony, the Technical Electrical Measurements Laboratory and the Calibration Room.

TECHNICAL ELECTRICAL MEASUREMENTS LABORATORY

Power is delivered to the Technical Electrical Measurements Laboratory by special feeders which run directly from the departmental substation. By means of throw-over switches, the feeders may be connected to either the motor generator sets in the substation or to the power house supply.

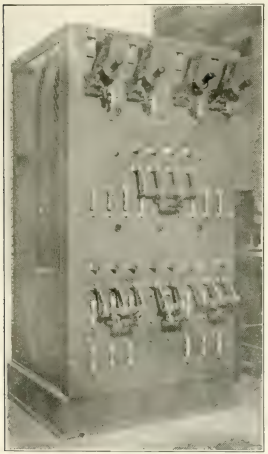


Fig. 2

In the laboratory these feeders connect with three main distributing panels which are equipped with switches, fuses and circuit breakers. (See Fig. 2). The following service is available for distribution from these panels: direct current, 230–115 volts; direct current from storage battery, 240–120 volts; alternating current 3-phase, 60 cycles, 230 volts, 4-wire; 2-phase, 60 cycles, 230–115 volts, 5-wire; and 3-phase, 24 cycles, 230 volts, 3-wire. The main distributing panels connect with 25 supply panels, which are located at convenient points in the laboratory and its adjacent rooms. Most of these panels are located around the walls of the laboratory, but four of them are mounted on standards and placed in the middle of the room for the purpose of supplying the tables used for meter testing and work of that nature. Fig. 3 shows the detail of one of these supply panels.

Power may be taken from the supply panels by means of the familiar arrangement of taper plugs and flexible leads. Connections which are of semi-permanent nature are made by clamping leads under cap screws and washers which are provided on all the panels.

It will be seen from the foregoing that current at substantially constant voltage and frequency and of excellent wave form is readily obtained at any point in the laboratory.

In the laboratory individual tables are provided for the experiments; this gives a very flexible arrangement and interference from jarring, etc., is eliminated. Because of the massive construction of the building, it is possible to support all the galvanometers directly on the walls without encountering trouble from the vibration. In order to facilitate the setting up of galvanometers, hoods, lamps and other apparatus, lengths of 2x4 inch wooden studding spaced 21 inches apart and fastened directly to the walls by bolts, which were set in the concrete at the time of

molding, are provided. This studding runs around the entire laboratory.

Between every two tables there are two 115-volt wall outlets, to which the galvanometer lamps may be plugged.

In the middle of the floor are located long tables which have backs consisting of uprights and 2 or 3 cross pieces. To these cross pieces it is possible to attach meters and other apparatus which are not sensitive to slight vibrations, such as would affect galvanometers. Experiments pertaining to the watthour meter,

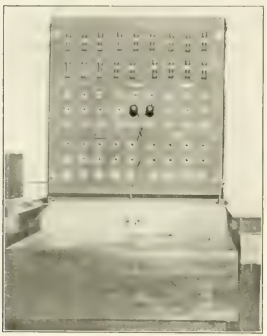


Fig. 3

the power factor meter, the demand indicator, the oscillograph, and the alternating current circuit are performed at these tables. Lamp banks are placed beneath the tables and selective switches are conveniently located so that a wide range of loads may be obtained. At one of the tables is located a special panel which controls a phase shifting motor generator set consisting of a direct current motor connected to two one-kilowatt, 3-phase alternators. Voltage may be taken from one of these machines and current from the other. It is possible, by means of a small motor provided with a remote control arrangement, to shift the stator of one of these alternators with respect to that of the other, and thus obtain any desired power factor, either lagging or leading. The range of frequency is from 18 cycles to 75 cycles per second. By means of specially designed field rheostats the voltages of the machines may be varied in small steps from zero to 300 volts.

The laboratory is also equipped with a special low voltage, high current storage battery and a stepdown transformer of high current capacity together with the necessary switchboard so that it is possible to obtain 2 volt storage battery currents up to 2000 amperes, and 5 volt alternating current, up to 5000 amperes. By means of control devices and series-parallel connections, the voltages and currents can be varied over a wide range. The storage battery is located in an adjoining room, and in the same room is the motor generator set, primarily designed for charging the battery but which may be used to supply current up to 150 amperes, at 8 volts, for laboratory experiments which do not require as constant a voltage as that given by the storage battery.

A Set Up Room, a Calibration Room, and a Dark Room are adjacent to, and connected with the laboratory. The Set Up Room is reserved for making preliminary investigations of an experimental nature such as are necessary in developing the work of the Technical Electrical Measurements Laboratory; thus the regular laboratory work is not interfered with and the special apparatus need not be disturbed until the investigation is completed.

The Calibration Room is to be provided with carefully calibrated secondary standards so arranged that it will

be possible, with very little trouble, to check any electrical instrument used in the department. The Dark Room is designed primarily for the purpose of developing oscillograph films and making prints.

THE HIGH POTENTIAL LABORATORY

The High Potential Laboratory is a division of the Technical Electrical Measurements Laboratory and is directly adjacent to it. It has not yet been possible to instal the apparatus, but it it hoped to have the laboratory in a usable condition within a few weeks. This laboratory is much larger than the corresponding one in the Lowell building, not only as regards floor area, but in overhead room as well. The latter is very desirable, as large clearances should be allowed for the high tension leads.

The 15-kilowatt, 230–100,000 volt transformer formerly in the Lowell Building, is now in position, and the protective case has been built around it. Two high potential bus-bars of iron pipe are suspended from the ceiling by suspension insulators, each insulator string consisting of 4 units; these bus-bars run the length of the room and make it possible to distribute the high potential to other parts of the laboratory when, for any special purpose, this may be desired.

A 15-kilowatt, 50,000 volt transformer having voltmeter coils in its high tension winding is a part of the equipment in this laboratory. The voltmeter coils make it possible to measure the high tension voltage without the use of multipliers or potential transformers. The power used in this laboratory for testing purposes is to be obtained from a 20 k. v. a. three-phase alternator driven by a direct current motor. For convenience of control and adjustment this set will be installed directly in the laboratory. The alternator is to be of special design and capable of producing substantially a sine wave under all conditions of load. This set will render it possible to cover a wide range of frequency and voltage.

An iron tank is set beneath the floor and is to be used in those tests where the specimen must be immersed. By a convenient arrangement of the valves which control the water and steam supplied to this tank, it is possible to control the temperature at which the specimen is tested.

Eventually this laboratory will be equipped with many other high tension devices to be used for experiments and for making high voltage measurements.

In addition to the above laboratories, which are primarily devoted to purposes of instruction, the Electrical Engineering Laboratories include the General Research Laboratory, where the work of the Research Division is carried out, and the Dynamo Research Laboratory, which, as its name indicates, is devoted to researches connected with electrical machinery. It is hoped that these two laboratories may be described in another communication.

THE HANOVER STREET BRIDGE BALTIMORE, MARYLAND

By EDWARD CAMERON

THE construction of the Hanover Street Bridge, at Baltimore, Maryland, presents a good example of the methods used in constructing piers on an unfavorable river bed, and illustrates the tower and chute method of distributing a large yardage of concrete over an extended area.

This bridge, now practically completed, is about 2300′ long, contains upwards of 40,000 cubic yards of concrete, 1600 tons of structural reinforcing steel, and 800 tons of round steel reinforcing rods. The retaining walls, arcade, and river piers rest on yellow pine piles, while concrete piles carry the south abutment.

The north approach end consists of a retaining wall section 219′ long, and an arcaded section which is 423′ long. The retaining walls are of the counterfort type with concrete ties to the opposite wall. There are 20 longitudinal arches in the arcade section with 2 transverse arches every 20′. These arches carry a beam and slab system supporting the roadway.

There are eleven river piers extending to 25′ below mean low water, with 2 piers each side of the bascule span which extend to grade —35. Typical river piers have a 3′ base slab, 26′x69′, surmounted by the frustrum of a pyramid 5′ high. This supports a 4′ core wall and 12 buttresses which carry the cap of the pier, a solid block of concrete 8′ wide and about 12′ high. On this cap the super structure rests. The specifications called for 250 yellow pine pile for each typical river pier.

At this point the river bottom consists of a bed of mud beneath which there is a layer of iron ore which proved almost inpenetrable.

The method used to construct the river piers was as follows. First the site of each was dredged out to 4′ below grade. Then the piles were driven. The first few blows on each pile sunk it to the water level, after which a follower was used to drive it down to grade. In order to get the specified resistance it was found necessary to use piles up to 65′ in length. Next the piles were cut off with a submarine saw at grade minus 22 for typical piers and at grade minus 32 for the 4 bascule piers. After the piles were cut off, the cofferdam for the pier was built of Jones & Laughlin steel sheet piling. The river bottom was so soft that it was found necessary to support the sheet piling on temporary wood piles in order to keep the tops of the former above water.

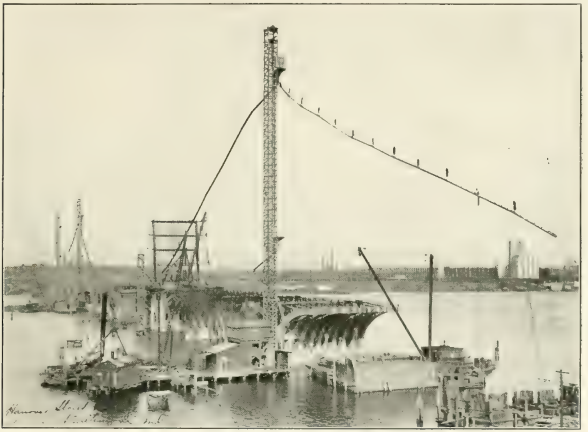
The next operation was to seal the bottom of the cofferdam with a 2′–0″ slab of 1–2–4 concrete placed under water and resting on the pile heads. By plumbing down, the smallest dimensions of the cofferdam were found, and the bracing framed to this size, allowing a little play between bracing and sheeting so that when the cofferdam was pumped out the pressure would crowd the sheeting tight.

After the bracing was in place, the cofferdam was pumped out, an 8″ centrifugal pump being sufficient to unwater it in most cases, after which a 3″ pump was able to take care of the leakage. From this stage on, no great difficulties were experienced in finishing up the substructure.

The superstructure consists of 12

arch spans and a 150′ double leaf bascule span. The arches have a clear span of 95′ with a rise of 24′ 9″. In fabricating structural steel, and for formwork for these arches, the rise was assumed as 25′–0″, thus allowing 3″ for camber. Each arch span is composed of 10 concrete ribs reinforced with structural steel trusses. The ribs are 2′–0″ thick, 2′ 6″ deep at the crown and eye bars from the adjacent span. All steel work is encased in concrete, the eye bars being wrapped with wire lath and plastered.

18″x20″ spandrel columns outside ribs support the sidewalks, while 15″ square columns carry the system of roadway beams and slabs. The reinforcement for these columns was originally designed as steel rods, but a struc-



THE HANOVER STREET BRIDGE, BALTIMORE, MARYLAND

about 7′–6″ deep at the skewback, one rib being located under each car track, one under each sidewalk, and 2 under each roadway.

Strictly speaking the ribs are not arches, but act on the cantilever principle. The expansion joint occurs at the crown and the thrust is taken up by 2—7″x1 1–2″ steel eye bars which extend from the crown to a steel tower at the pier, being balanced by similar tural steel column with angles having an equivalent area was substituted, thus saving the labor of handling separate reinforcing bars. The roadway is 50′ wide, curb to curb with 8′ sidewalks.

The structural steel ribs were fabricated at the Maryland Steel Company's plant, at Sparrows Point, and were loaded on a lighter, 10 at a time, and towed to the site. They were made and erected

in umbrella-shaped units each weighing about 10 tons.

Bottom forms for the ribs were made of 2″ yellow pine lagging spiked to 2″ joists sawed to the curve of the arch ellipse, and located under the lower chord angles of the steel ribs. Five-eighths inch bolts hung these forms from the chord angles. The side forms rested on the bottoms, and were spaced from the steel by spring steel wire clips which were snapped over the angles and spaced the forms 3″ from the former. These side and bottom forms were made up at a local mill according to detail drawings and were assembled in units of approximately 30 square feet.

While the concrete was green the 5–8″ bolts carrying the bottom forms were given a couple of turns to break the bond with the concrete. Later when it was time to strip forms it was found that practically all of these bolts could be unscrewed although a few had to be cut off.

Thus it will be seen that the structural steel ribs served the double purpose of providing reinforcement for the concrete and carrying the concrete forms, thus doing away with the expensive piling and false work in the middle of the river, which would otherwise be necessary.

To place the large amount of concrete required for this job, over such an extended area was a proposition which took a lot of study to decide. The system adopted was a tower and chute plant. One mixing plant was located on shore at the retaining wall end, one at pier 5, and one at pier 13; the latter two being supported on pile platforms in the river. Towers 200′ high were built at the mixing plants with elevators to raise the concrete to hoppers, from which steel chutes, hung by tackles from guys could place the concrete at any point within a radius of 450′.

By this means it was possible to place 350 cubic yards of concrete in a nine-hour day, and it was found that a carpenter gang of over 50 per cent of the whole working force were kept busy on forms in order to keep ahead of the concreting force.

Three sets of arch forms were made up in advance. All the form-work for this job had to be particularly well braced due to the speed with which concrete was placed by the chutes in contrast to the slower method of placing with wheelbarrows, as practised on smaller jobs. By the former method a relatively greater depth of concrete is poured at one time so that there is no chance for the lower layers to get the slight set which ordinarily relieves the lateral pressure of the concrete to some extent.

Exposed surfaces of the piers and ribs were given a very coarse bush-hammered finish, while the balustrade received a carborundumed rubbed finish.

The accompanying pictures show the general design of the bridge and give a good idea of the layout of the construction plant. The frontispiece shows sections at all stages of construction. At the extreme left, the retaining wall and arcade sections may be seen. South of these several spans are shown, completed except for the balustrade. One leaf of the bascule had been erected at this stage of the game. The cantilever construction of the bays is shown at pier 13, just in front of the tower at the right, while the cofferdam and substructure of pier 14 appear just south of pier 13.

In the illustration on the preceding page we see the concrete tower at pier 13, also the suspended chutes. A hopper is shown part way up the tower with a chute delivering concrete to the substructure of pier 14, the cofferdam for

which appears in the foreground. The mixing plant for this tower may also be seen in the foreground. On the shore at the right is a pile of bottom forms for the arch ribs, all ready for erection, while a relay tower is seen south of the tower at pier 13.

The Hanover Street Bridge was designed by the State Roads Commission of Maryland, H. G. Shirley, Chief Engineer, and J. E. Greiner, Consulting Engineer, and was erected by H. P. Converse & Co., General Contractors, of Boston, during 1915 and 1916.

"BLACKIE"

IT is said by one of the Institute Faculty who traveled last year over the country, meeting many of our graduates in the large centers and in the lonely places, that almost invariably their first question was "And how is Blackie?" When they had found out they would remember to ask about the new buildings.

A good many of those graduates were remembering the Convocations in old Rogers a few years back, when as the room filled and the appointed hour drew near, the boys would begin to shout with concerted emphasis "Wo ist Blackie?" Then as if on a signal he would appear, shaggy gray head bent and darting from side to side in his quick and courtly bow, eagle nose above rampant gray moustache and imperial, black eyes brilliant. And the shout would go up "Blackie ist gekommen!" The Convocation might convoke.

A certain disrepute attaches to the word "character" when it refers to a person of marked individuality. But if "character" means one whom having once seen you could not forget, of strong and genuine personality, of picturesque and kindly exterior, unfailing good spirits, cordiality and courtesy, of originality and humor absolutely individual, forever giving of his interest and affection and receiving as he gave — then, by nearly twenty-five years of loyal and affectionate remembrance among Tech men, Mr. Blachstein was a character!

We knew very little of him. He was always eager to ask about our interests; he always remembered, often over long intervals, the things we were doing; he seldom forgot a name or a face. But he never talked of himself or obtruded his interests upon us. He was as modest as he was kindly. Even at the last, it is said, he did not wish the notice of his funeral to be published in advance at the Institute. We do not know of his early life, save that he was born in 1851 in Thuringia, and that when over forty he came to America and for the first time took up teaching. He was an old man when he died. But his twenty-five years of life in America, nearly all spent for us and our fathers at the Institute, must circumscribe our picture of him.

Although his originalities were perhaps the first attraction for his students, these alone could not have kept their affection. And he did keep their affection — he never missed an Alumni dinner and seldom a class or athletic dinner or show Kommers; he was always asked to speak and did speak, quaintly, humorously and wisely. There is proof enough.

His very grotesques were part of his affection for the world at large. He must have loved making people smile at him and with him. His elaborate ceremonials of salutation, his trick of falling into rapid French — which I have been told was excellently pure — his little stunt, in which he took great pride, of being able to tell you the day of the week on which any date of any past year had fallen, his puns and

jokes upon every subject under the sun including his pupils' names, his unfailing inquiry about your rubbers and umbrella if you had a cold, his flagrant and undeserved compliments to you — these were no mere surface eccentricities. He bowed and smiled whether he knew you or not; he always spoke first. At his funeral the officiating clergyman said that among the large and floating population of that part of Roxbury in which he lived, hundreds who never knew his name, and whom he could not have known, had him for a bowing acquaintance, knew him for the friendly courteous gentleman he was.

It is good to think that he saw the Institute enter its larger life, that he had a last opportunity of seeing again his old and remembered pupils among the thronged Alumni last June. It is good to think he could work—even for a little while—in the New Tech. But did he not deserve more than that? He served the Institute twenty-four years. He was not a scholar, he was not even a University man. But every undergraduate whom I have asked has told me that he was a faithful, enthusiastic, inspiring and uniformly successful teacher. They did learn of him, willy-nilly. It is a pity that he should have died without the promotion to which his long and faithful service —and successful if the suffrage of generations of students is to have any weight — ought to have entitled him.

It is said that at a little club of his intimates which he frequented he showed a poet's gifts in the writings he would upon occasion recite. We did not know that, but surely we might have guessed it. Even if he had never written a verse he was a poet, an artist in the relationships of life. He transcended, somehow, our curt and unexpressive American daily life. He was a figure of the old world — I had almost written of an old world romance. He wore the mustache and imperial of the Second Empire; one could almost see on his bent shoulders the shadowy fullness of the cloak of an earlier generation. His manner had a whiff of the romantic thirties. Balzac might have written him.

Even during this last year when he must have been suffering he never let us know it. He always made us smile, always left us feeling a little more at home in the world. His passing leaves us somehow, with a sense of an actual loss in the pleasant custom of the world, in its courtesy and kindness and pleasantness, in short in that laughter which is born of consideration and fellow-feeling. There are qualities some of us think, which are more necessary to a teacher of young people than scholarship. Our friend — laughter-loving and dead—had many of these qualities. One can imagine him dying, like Mercutio, with a whimsical, affectionate joke at the grief he was causing us.

He was a verray parfit gentil knight —and we laughed at him because we loved him.

ROBERT E. ROGERS.

THE HISTORY, DEVELOPMENT AND EXTENSION OF THE ELECTROMAGNETIC SPECTRUM

By H. P. HOLLNAGEL, Ph. D.
Dept. of Physics, M. I. T

II.

VISIBLE SPECTRUM

PERHAPS it is unfortunate that we have come, in the chronological development of our subject, to a subdivision as previously indicated.

It seems, however, better logic to proceed in this manner at present than to make any attempt at radical departure.

Two factors are unconsciously influencing daily the results which are attained in science; *i.e.*, the apparatus used and the conditions under which observations are made. As a natural consequence the classification given in the previous article has been presented.

We have come to speak of a visible spectrum because of the effect which certain electromagnetic radiations produce upon the eye. Had it been possible to have had systematic observations made by prehistoric man who knows but that the results, exceedingly interesting and important, might not have been confined to a region other than that we are prone to refer to as the visible.

It is reasonable to assume that custom has, in a large measure, subconsiously impressed upon the human intellect certain visual effects now usually referred to as facts, but there is no certainty that the five effects mentioned at the close of the last article may not all be active in the production of sight. Sight is, at best, but a physiological effect of an external cause which may be effected by psychological conditions.

In fact, there have been electromagnetic conceptions of this phenomena presented which appear to be satisfactory hence why especially refer to radiation as visible radiation for any other reason than that custom has so taught?

Presenting the subject in the order of its development we proceed first to discuss the visible spectrum.

When, in 1672, Newton—who had already supplied the world with many interesting facts—presented his treatise on Optics to the Royal Society, little was it thought that "the lights which differ in color differ also in refrangibility" was but the advance guard of an army of results to be attained in the succeeding centuries of investigation.

As his experiment is not known to all it may not be out of place to call attention to the simple facts—Sunlight passing through a circular opening in a window shutter of his room was allowed to fall upon a triangular prism of glass and the rays that emerged from the latter were examined upon a white screen: not only did the prism spread the white light out into its various component colors but it bent them from their original direction to different amounts.

Having used the sun's rays as a source Newton referred to this as the Solar Spectrum, ascribing seven funda-

mental colors to it but fixing no feasible limitations thereupon. This would be as natural to the lay mind today as it was perhaps at that time to the investigator. Any such limitations which might have been ascribed to the region of energy, designated as the visible spectrum, could, in the strictest interpretation of the term be but an arbitrary one. Different individuals have varying range of color sensibility as well as color vision, both of which are influenced decidedly by environment and psychological conditions. (To justify this it is but necessary to cite the increased sensitiveness of the eye to the extreme regions of spectrum after continued rest in a dark room.) Furthermore, the determination of such limits would have had but little significance in terms of the apparatus utilized. Not until permanent apparatus possible of exact reproduction had been designed and became more generally known could real value have been attached to such a procedure.

In 1802 Dr. W. H. Wallaston (1766–1828), while working with apparatus similar to Newton's observed a number of dark bands crossing the visible region of the spectrum. These Newton had not observed as a consequence of overlapping spectra resulting from the use of a circular slit through which the sunlight passed. The results of the first-mentioned, however, received little attention. In the same year Thomas Young calculated the first wave lengths, from interference considerations of thin films, for the various colors, thereby fixing the initial landmarks in the spectrum. He placed the lower visible limit of the red end at 6750 Ångström units and the upper limit in the violet as 4240 Ångströms. (An Ångström unit is 10^{-8} cms.)

Ten years later Joseph Fraunhofer (1787–1826), optician and glass manufacturer, while using decomposed sunlight as a means of studying the achromatic properties of a telescope lens observed the numerous dark bands crossing the solar spectrum and immediately proceeded to map them.

The more important he designated as the A, B, C, D, E, F, G, H lines, the A and H lines being about the extremes he ascribed to the visible red and violet respectively. Later, in 1821, he directly determined the wave-length of a great number of these lines. This was accomplished by means of a diffraction grating, made by winding wire around very fine screws held rigidly in place; thereby Fraunhofer was able to test the theory of diffraction which he had worked out mathematically, and presented before the Munich Academy of Science that year.

His determination of the wave length of the sodium D line stands as a model of precise measurement for its time. This was a decided advance as it made possible not only the calculation of achromatic lenses—for the dispersive power of the glass could now be calculated—but also the use of fixed wavelengths in the visible spectrum as positions of reference. The extremes, as fixed by the B and H lines, were given as 6879 Å and 3926 Å respectively. (Though the A line had been recorded he had, apparently, not determined its wavelength).

The stupendous importance of the next discovery (1859),—the application of the spectroscope to qualitative chemical analysis and its direct astronomical interpretation by way of the Fraunhofer lines—cannot be passed without at least calling attention to a popular classical experiment known as "the sodium reversal." It is understood that the character of the spectrum emitted by a body is dependent on the physical state

of aggregation of the substance in question. In general it is an approximation to the true conditions to refer to the spectra of solids when incandescent as continuous, while those of gases are discontinuous; *i.e.*, banded or bright line in character. If then the luminous energy of an incandescent solid like the positive carbon of the electric arc lamp is examined spectroscopically a continuity of color from red to violet will be observed. The radiant energy from incandescent sodium vapor, for example, however, will show but two distinctly bright yellow lines, designated as D_1 and D_2. Examined simultaneously—when sodium is placed in crater of the arc—an approximately continuous spectrum with the two bright lines referred to superimposed upon it is observed.

Assuming this condition to exist, suppose a quantity of sodium vapor, at a lower temperature than the carbon-sodium arc, is interposed between the source and the spectroscope, what would be observed? A continuous spectrum with two dark bands replacing the former bright ones, indicating that the cooler vapor has absorbed substantially all the energy that the hotter emitted. Experiments of this character widely extended the range of our knowledge of the universe.

Kirchhoff (1824–1887), and Bunsen (1811–1899), conjointly indicated the persistency throughout the universe of all such elements as it was within their power to investigate in the laboratory. They insisted that such absorption lines in the solar spectrum were due to the absorption by vapors and gases in the sun's atmosphere for rays originally present in the solar emission. In a few words the sun, and several of the planets and fixed stars were qualitatively analyzed in a physical laboratory—though ninety million miles, or more, separated analyst and specimen offered.

More definiteness was given the mapping of the Fraunhofer lines of the sun's spectrum and the bright line spectra of comparison by very precise determination of the wavelengths and the establishment thereby of the first "Normal Solar Spectrum." This was the work of Anders Jonas Ångström (1814–1874) of Upsala, Sweden, who in 1868 took up Fraunhofer's work, and not only repeated but widely extended it. Partly because of its utility, as well as in admiration for this excellent work, it is customary to express wavelengths in the unit used by this investigator, *i.e.*,—10^{-8} cms., called one Ångström.

The setting of the standards in the wavelength advance then ceased until Henry Rowland (1848–1901), of Johns Hopkins University, Baltimore, found it necessary to construct an exceptionally fine diffraction grating in order to obtain a monochromatic source of light for use in other experiments. In so doing he was diverted from his original purpose into repeating all of Ångström's original work on a much larger scale.

He re-mapped and re-determined the wavelength of all Fraunhofer lines in the solar spectrum, thousands in number, and though this map is twenty meters long it is said to be precise to .01Å. This is given merely to call attention to the precision with which this physicist had worked.

The extreme approximate limits of visibility, as now generally accepted, are given as $\lambda = 7500$ Å in the red, and $\lambda = 4000$ Å in the violet for the normal eye. This does not mean that physicists have not been able to observe beyond these wavelengths, but that, under normal conditions they are the most probable extremes.

We will now proceed to a considera-

tion of more recent evidence of the electromagnetic character of visible light.

About 1875 Kerr showed that an electric field will cause a ray of light entering a transparent medium normally to traverse two distinct paths; that each ray within the medium has a characteristic plane of vibration as well as an index of refraction, *i.e.*, the electric field causes double refraction. Two years later he observed still another result of great interest—light, when vibrating entirely in one plane, was allowed to fall normally upon the polished metal surface of the pole of an electromagnet, that which was reflected had its "plane of polarization" rotated an amount which depends upon the strength of the magnetic field.

Faraday, and many succeeding investigators, had attempted to obtain an effect of a magnetic field on the Sodium D lines—none, however, had been successful up to 1896 when Professor Zeeman of Leiden succeeded in establishing the desired results. If a light source is placed in a magnetic field and viewed in a direction at right angles thereto, a characteristic bright line in its spectrum, which is single when not under magnetic influence, appears as three lines when magnetic field is active. The plane of vibration for the two outer lines appears to contain that of the magnetic field while the central band has its plane at right angles thereto.

For an observer looking along the lines of magnetic force the single line of the spectrum without magnetic field appears as two in the field. The latter are circularly polarized in opposite directions, meaning that the continued motion of ether particles, in a plane normal to the direction of advance of the light wave, is circular either right or helf-handed.

As early as 1887 Hertz had noticed that the poles of an electrostatic influence machine were discharged more readily when illuminated.

This led Hallwachs in 1888 to the discovery of another property of light; *i.e.*, the "photo electric action." If a charged plate is exposed to light it is well known that it will be discharged. It is found that the number of free negative charges escaping, as well as their velocity, is determined by the character of the metal, the wavelength, intensity and polarization of the incident light, and the angle of incidence.

In the so-called "normal photo electric effect" the number depends only upon the quantity of light absorbed. In the "selective photo electric effect" the number depends on the amount of light absorbed, the angle of incidence, and is a maximum for a particular wavelength, but smaller for wavelengths of either greater or less value.

More recently Johann Stark has been able to show entirely analogous results to those of Zeeman, though in this case the effects were obtained by an intense electric field acting on the light source.

Certainly if any doubt existed at the time when Hertz announced his famous experiments, it would now, after such a brilliant array of results, disappear as "dew before the sun." However, there may be still skeptical ones to whom is recommended a brief resumé of the recent work of one of our own graduates—George E. Hale, Director of the Mt. Wilson Solar Observatory, Pasadena, Cal. By means of that ingenuous device invented by him—the Spectroheliograph—he was able to photograph the solar disc during the period of maximum sun-spot activity and to study its character.

His most recent photographs actually show a vortex formation, and it is found

that the direction of rotation is both right and left-handed. In view of this, and information obtained in the laboratory on the electric discharge of high temperatures, it appears scientifically possible, as a result of such vortex motion, to cause a magnetic field in the solar atmosphere. Should this be the case, reasoned Hale, some of the irregularities in solar lines at sun-spot maxima might be explained by the Zeeman effect. He therefore sought the latter in the sun at such times and found the evidence. Going further he actually determined in his laboratory the order of magnitude of the magnetic field necessary to produce the polarization effects which had induced him to conclude a magnetic field to be active in the solar atmosphere.

THE LIGHTING OF FACTORIES

By FREDERIC NEWLIN PRICE, A. B., Swarthmore, '05.

Editor's Note. Within a year or so after you graduate from Tech suppose that the proposition of lighting a new addition to a part of the factory you were working in was put up to you. How would you go about it? What would you do?

We feel very fortunate in being able to present this article, which is the first of a series on Illumination Engineering. For seven or eight years Mr. Price was in the Holophane Shade department of the General Electric Company. He recently left them to take up a field of lighting more to his liking. This series of articles should help you in a field of engineering that is daily growing in importance.

THE industries of this country are to be busy night and day for the next decade. Today in all parts we find the American factory unable to supply the demand, and it has come to be a nice question to pick and choose. Big orders go begging. In such a situation it is well to look into all the phases which will help in production. The artificial illumination which promotes efficient production is not the least important. Should the lighting permit operating efficiently day and night, it cuts the fixed overhead burden laid on all output—such charges as interest on investment, taxes, etc.—are spread over twice the former output. Thus the set charges have their power in ratio.

Labor and material, the unfixed and variable quantities of the factory, are even more affected by illumination. If we consider labor, there is the loss of time in moving lamps so that the men can see. Low visibility or too high visibility create weakness in the visual oculty of the worker. It is figured that good illumination increases the efficiency of operators not less than 16 2–3 per cent,—that is they turn out that much more value in the same time in a well-lighted factory. There is a loss in machinery and time when breaks or faults occur in dark areas.

As to materials, the spoilage is decreased by good light. This is especially true of piece work—where operators speed up to increase their bonus. Defective goods may pass through; if they are caught they must be done again.

Furthermore,—there is the vital item of accidents,—almost all the casualties occur during the dark days of the year and can be charged directly to inefficient illumination. The man and the machine must be a unit—we oil the machine and carefully design it to do something in the light, it is not built to work in the dark.

There are no difficulties in the problem of good lighting—the world is rich in tools of illumination. First we can require 3 to 12 foot candles intensity as need may be,—we may require that the light be shielded from the eye, 26 degrees over the horizontal or hung in a metal bowl type shade that redirects the light on the working plane. Foot candles are prescribed by usage and the figures given in Table I will be found dependable. In figuring out the above result for any given space, multiply the area of the space to be lighted, expressed in square feet, by the intensity, in foot candles, desired, and divide that amount by the available or useful candle power from the light source to be used. In almost all cases the incandescent electric lamp is the most desirable, being clean, mechanically perfected, free from fire risk and easily obtainable.

Kind of work	Foot Candles
Desk Work	4.0
Carpenter shop	2.5
Draughting	8.0
Engraving	12.0
Bench work	4.0
Foundry	3.0
Garage	2.0
Laboratory	3.0
Stock Room	1.5
Pattern Shop	3.0
Power House	2.5

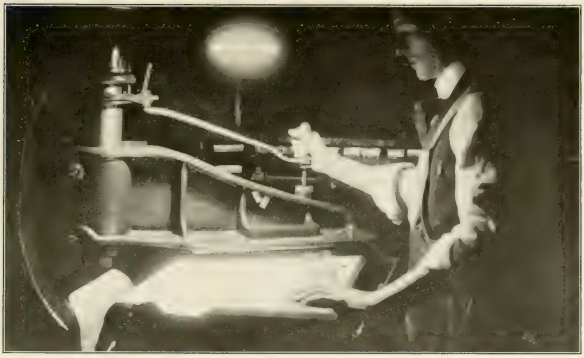
steel or glass, using small units from 10 to 50 feet apart.

In the work room there is a difficult question, for the light must be thrown on the work and out of the workman's eyes. Here we have found only one successful reflector,—the deep bowl, made of steel and coated with a good

This room has 400 looms, each lighted by one and one-half 60 watt Intensive type reflectors, using Mazda lamps. The mill operates at as high efficiency under artificial light as it does during the day. Note the protection of the eye and the brightness of the working plane.

Let us assume that you have obtained the above data,—first area in square feet, then intensity needed, then divided it by the flux of useful light. We have still before you the problem of distributing the light rays—redirecting the light down to the working plane. Two systems present solutions: General and Local. We may light a stock room or shipping room with general illumination. The problem is easy for we may use the bare lamp or a flat redirecting surface of reflecting medium. With such a reflector we can send the light in much the same way as we use a garden hose,—all in one spot, over a narrow area or to a broad area, as the situation requires. We call these distribution Extensive, Intensive and Focusing. This specific system together with general lighting makes for the better installation.

The reflecting medium is of importance. Since we are considering factories we will use porcelain enamel in those



Showing how proper illumination protects the eye of the workman and throws the light on the work, not the workman.

Showing how improper illumination throws the light in the eyes of the workman and improperly lights the work.

places where moisture prevails, and we will use the aluminum finish on steel where we have dry conditions. Mr. Bell gives the reflective qualities of various materials as shown in Table II.

Material	Per cent Reflection
Polished silver	92
Mirrors	70 to 85
Polished brass	70 to 75
Polished copper	60 to 70
Polished steel	60
Polished gold	55 to 55
Burnished copper	40 to 50
White blotting paper	82
Foolscap	70
Chrome yellow paper	62
Light pink paper	36
Blue wall paper	25
Dark brown paper	13
Vermillion paper	12
Glossy black paper	5
Black cloth	1.2

The aluminized steel reflecting from 60 to 85 per cent is the most economical value as yet produced, if properly applied.

Undoubtedly the accompanying illustrations will show what is meant by good illumination.

FIELD DAY

By A. E. TUTTLE, M. I. T., '17

Editor's Note. Various of the Alumni have signified that they would like to know a bit more of the Undergraduate affairs at Tech and how they are carried on. Field Day is the largest of Undergraduate athletic events of the year, and from the following they may readily see how this is carried on in comparison to the way things were when they were in the Institute.

DURING the fall of the year, in nearly every college in the country, there is an annual outbreak of the class rivalry existing between the Sophomores and the Freshmen. This outburst usually takes the form of either a fight, a cane rush, or, as we now have at Technology, a field day.

In the early days of the institute this exhibition of class spirit took the form of a cane rush that grew more and more dangerous as the number of participants increased with the growth of the school. Finally, in 1900, the long-expected accident occured, and when the rush terminated it was found that H. C. Moore, a freshman, was dead, and H. W. Sherril was suffering from a hemorrhage and an enlargement of the heart from which he never fully recovered. The natural result of this accident was the elimination of the cane rush and a committee was appointed to confer with the Advisory Council on Atheltics upon a proposal to have a field day, with athletic events, to take its place.

The committee drew up plans, which vary but slightly from those now followed, to be carried out the following year (1901). After careful consideration these three events, a football game, a relay race, and a tug of war, were chosen not only because they required a large number of men, but also because they offered positions for which almost everyone could compete, thereby making the teams as nearly representative of the class as possible. In order that there might not be a tie unless all three events were tied the scoring adopted was as follows, the football game four points, the relay race three points, and the tug of war two points. Good playing and team work add a great deal to make such sports interesting so for this reason practice starts immediately after school opens in the fall and continues until field day, the first Friday in November. The Freshmen teams are all in charge of Juniors appointed for the purpose while the Sophomores select their own managers. The football teams hire coaches and Frank Kanaly, the regular track coach, takes charge of the relay teams. The interest taken in these teams due to class spirit is further stimulated by the award of class numerals to the football teams and to the winning track and tug of war teams.

The Seniors and the Juniors as well as the lower classes take an active interest in field day and a large per cent of them march in the parade. This year, being the first in our new quarters, it has been necessary that the program of the day be varied slightly. The classes now form in the large great court, seniors at the main entrance, and the other classes around at the different corners. At the stated time the parade starts for the field, a band at the head, and then the Seniors, Juniors, Sophomores, and last the Freshmen. The band which leads the parade, composed entirely of students, is capable of rendering music, hardly sublime but nevertheless recog-

nizable. Upon the arrival at the field the different classes take up sections designated for them where they can expel surplus enthusiasm through the medium of cheers.

When the field-day games are over the winning class performs a snake dance upon the field, and after the final cheers for the victors all depart to meet at some show house in the evening.

Finally as a closing feature all participants in field-day contests, judges and other officials, meet on the following Saturday night for the field-day dinner. Here, after speeches by members of the Advisory Council expounding the advantages of participation in activities the beautiful silver championship cup, upon which the winning classes have their numerals engraved, is passed from hand to hand and each man before he drinks gives his name, class, and the town or city from which he comes.

HEAT TREATMENT OF WROUGHT IRON CHAIN CABLE

The following from the *American Society of Mechanical Engineers* gives an interesting summary of one of the papers prepared by Tech men and read at the annual meeting of the Society this month in New York.

EXTENSIVE investigations have been conducted at the Boston Navy Yard on methods for heat-treating power-forged chain cable, under the direction of Frederic G. Coburn, Naval Constructor. The work was done largely by W. W. Webster and E. L. Patch, assistant naval constructors and graduate students at the Massachusetts Institute of Technology.

All the chain cable for the Navy are made in the Smith shop of the U. S. Navy Yard, Boston.

Previous to July, 1914, this chain was hand-forged and came up to all requirements without heat treatment. At that time, however, the process of manufacture was changed by the introduction of power forging and test links repeatedly and consistently failed to come up to the required strength. The fracture almost invariably occurred across the welded quarter, not in the weld, and showed a rather coarse granular structure. The links showed little tendency to change shape and stretch before breaking, as did the hand-forged links.

It was evident that the unannealed links were too "stiff"; that is, while the material was strong enough in direct tension it was not ductile enough to get the full benefit of the tensile strength, on account of the shape of the link. Because of this stiffness, the shear across the bent quarter would reach its limiting value long before the direct stress. The annealing relieved this stiffness and produced a relation between the strength and ductility of the metal which greatly increased the strength of the link. It was evident that in order to obtain uniform and satisfactory results a systematic investigation of the whole subject of the heat treatment of wrought iron cable should be made to develop scientific methods to replace the cut-and-try methods formerly used.

Accordingly a complete laboratory was equipped for this purpose at the Navy Yard and systematic tests were conducted, first on the stock material used in the manufacture of chains and later upon links taken from the chains themselves. These tests included chemical analyses, tensile and impact tests, and metallographic examination. Preliminary to the tests on the full-sized chain links, large experiments were conducted on heat-treated specimens of the material.

The paper gives the results of several of these series of tests with conclusions.

EDITORIAL SECTION

The Technology Monthly
Engineering Journal

A MAGAZINE DEVOTED TO THE INTERESTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BOARD OF DIRECTORS

Editor-in-Chief
LINWOOD I. NOYES, '17.

Business Manager
FRANK C. HOWARD, '17

STAFF

Advertising Manager
R. E. DEMERRITT, '18

Circulation Manager
H. P. GEISLER, JR., '18

Treasurer
W. L. DENNEN, '18

Publicity Manager
E. F. ROSSMAN, '18

Staff Photographer
F. H. NORTON, '18

Art Editor
L. F. VAN ZELM, '18

GENERAL STAFF

H. F. GOLDSMITH, '17
G. W. ROOT, '19
R. K. WELLS, '19
B. I. LEWIS, '17
M. M. STETLER, '18
J. C. BRAISLIN, '18
G. M. MACHECA, '18

General Offices of the Publication, Mass. Inst. of Tech., Cambridge, Mass.

Secretary of the Association of Harvard Engineers, 218 Pierce Hall, Cambridge, Mass.

All Positions are open to competition.

All manuscripts submitted for publication in the TECHNOLOGY MONTHLY ENGINEERING JOURNAL should be accompanied by the writer's full name and address. Manuscripts not accepted for publication will be returned only if the author so requests. Photographs, drawings, etc., will be returned to the contributor immediately after publication.

Forms close the 28th of the month immediately preceding date of publication. Material specially arranged for may be received up to the fifth day following.

EDITORIAL

BEARDLESS CHINS

"OLD men hold far too obstinately to their own ideas. That is why the natives of the Fiji Islands kill their parents when they grow old. In this way they facilitate evolution, while we retard its advance by founding academies.", One smiles—the inimitable Anatole France, in the double role of epigrammatist and satirist—his epigrams with just sufficient truth to establish his point, and the shafts of his satire just sufficient to destroy the illusion he creates.

The shot strikes home however, despite the satire. Again and again it has been shown us that today is the day of the young man. There is no valid reason why this should not be so. Judgment does not come as the result of living longer than one's fellowmen—the old saying: "no fool like an old fool," is a recognition of the fact that the quality of foresight, of prudence, of level headed thinking, of all those essentials which we include in the phrase "good judgment" are not the product of long years of life, but the result of the well disciplined and trained mind. "Experience is the name men give to their mistakes"—another phrase of that epigrammatic variety with enough truth to be worthy consideration, and again a recognition of the invalidity of the claim of age to wisdom.

The catchwords of writers aside, it is sufficient to look about us to be convinced of the facts. The foremen and managers of great industrial plants, leaders of industries, heads of national concerns, magnates, captains of industry, each generation sees them grow younger. Perhaps it is the increasing nervous strain of modern life that makes the older men unfit, perhaps the pace grows too fast for any man to keep with the leaders for more than a certain time. Perhaps and perhaps not. Mr. Chauncy Depew would assure us that we are wrong. So also might others. People are at present pointing to the European war as a war of gray beards. But how many of the gray beards who were supreme two years ago are at the helm today? Joffre is the only one. French, Von Kluck, Von Moltke, Von Falkenhayn, all discredited, all fallen from their high power, and more will follow shortly we are told. Today the men whom the English realize are the greatest bulwarks the nation has, are young men—Jellicoe, Beatty, Churchill. And in Germany, von Hindenburg indeed is chief of staff, but rumor has it that the man of action, to whom von Hindenburg is a cloak, is Ludendorff, young, unknown, but at the helm.

It is one thing to realize the facts, another to take advantage of them. The world is the young man's oyster. But the weapons which he must use if he would "it ope" must be chosen with care and industry. That is why we are at Tech. That is why we spend long years in preparation. The trouble is that in the hours of drudgery we are liable to forget this. Our ambitions become less vivid as the

onus of daily labors demands more and more of our attention. And we come to regard Tech more as a place to get out of and drag with us the precious degree, than as the workshop in which we mould the weapons we must use on the morrow.

Remember, the training we are receiving now is that which must pass through fire and flood hereafter. The tools we are grinding now are those on which we must depend for a lifetime. It is not only the absolute knowledge we can gain, but the methods of approach, of attack, habits of mind, methods of thinking, of working, which will tell in the long run. If we are to be *the* young men who shall carry the burden of the world's work, it behooves us to acquire those qualities which will make our leadership necessary to our fellows. The proper application of our energies, the proper balance of our activities and interests, the proper development of our individual possibilities, these are the things our training should give us. These are the things which we should weld during our years at Tech into a mighty power, a strong weapon, a strength precious both to ourselves and our fellowmen

PERCIVAL LOWELL, HARVARD, '76

IN our last issue we spoke of Dr. Lowell's latest lecture tour and commented on the opportunities which were being offered to students all over the country by this trip. Several days after the issue appeared the world was startled by the news of his sudden and unexpected death at his observatory at Flagstaff, Arizona. His death deprives the world of one of the very few men of independent fortune who have devoted their lives to pure science.

In 1849 he founded an observatory at Flagstaff for the study of planets. Here he accomplished research work which entitles him to an honorable place in the history of astronomy. Undoubtedly just what place this will be depends on how time deals with his theories of the presence of intelligent life on Mars. If the advancing march of science ever places the plausible hypothesis that Mars is inhabited within the realms of ascertained fact, then Percival Lowell will stand for all time in the front ranks of the learned men of the world.

GET BEHIND THE BAND WAGON

WE who are in the 'Stute now shall always remember the class that went out as the last from the old Technology across the river as a great class. They stood together, they were solid behind their leaders, they left to us a heritage of spirit worthy of the Technology of old.

Fellows, is not the New Tech worthy of the same spirit? Have we not a legacy which it behooves us to hand down to those who will come after us? We have our leaders, men who are as capable and enthusiastic as any who have gone before. Let's back them up. Let's help them in the things they are trying to accomplish. Granted we are laboring under the disadvantage of great disorganization due to

new and untried conditions—should we not therefore put forth extra efforts, strain a little harder at the wheel, to help those at the head of things in their more complex problems?

1917 will be the first class to leave the New Technology. Do you Seniors realize that you are expected to lead the pace, to set the example? Don't you understand that the spirit you show will be echoed by succeeding classes?

Up, then, and rally around your chosen leaders. Give them the aid and support they ask. Surely it shall not be said that 1917, the first class to represent the Institute in its new dress of magnificent promise, was tried and found wanting.

THIS year the annual meeting of the American Society of Mechanical Engineers was held in New York City during the first week of December. It is very gratifying to note the large part that Technology graduates played in this meeting. Eleven graduates of Technology had part in the preparation and reading of the forty papers read before the Society, and a large number attended and took active part in the discussions.

VENUS
10¢ PENCIL

17 Perfect degrees for any and every purpose.

FOR sketching in heavy back grounds or bold effects, you will want a soft heavy, smooth lead such as 4B, 5B, 6B VENUS. For fine detailing the higher number H's are perfect, 3H, 4H, 5H, 6H. For graphical charts, etc., degrees as high as 9H are often desirable.

Uniform, unvarying, flawless VENUS pencils satisfy any requirement no matter how difficult it may be. 6B is softest of the 17 degrees, and 9H is hardest. Specify VENUS and look for **distinctive VENUS water mark finish** when you buy.

Your professors will confirm these statements as to the merits of VENUS pencils

For Sale by Your Supply Store
Our Service Selective

AMERICAN LEAD PENCIL CO.,
215 Fifth Ave., Dept. Q,
New York

VENUS ERASER

This is of even texture, and cleans beautifully. Gray in color and does not discolor or damage the most delicate materials. Made in 12 sizes from 1 to a box to 100 to a box. Box price, $2. You'll find the Venus Eraser is the best eraser you ever tried

"Say, jeweler, why doesn't my watch keep good time?"

"The hands won't behave, sir; there's a pretty girl in the case." Cornell Widow

Dancing, dancing, little star,
How I wonder what you are,
Prancing there upon the stage;
Buxom youth or padded age? —Pelican

MILEAGE PER GALLON

Willis—Just think of it! Those Spanish hidalgos would go three thousand miles on a galleon!

Gillis—Nonsense. You can't believe half you read about those foreign cars. Life

HIGGINS'

DRAWING INKS
ETERNAL WRITING INK
ENGROSSING INK
TAURINE MUCILAGE
PHOTO-MOUNTER PASTE
DRAWING-BOARD PASTE
LIQUID PASTE
OFFICE PASTE
VEGETABLE GLUE, Etc.

ARE THE FINEST AND BEST GOODS OF THEIR KIND
AT DEALERS GENERALLY

CHAS. M. HIGGINS & CO., Manufacturers
Branches: Chicago, London **271 Ninth Street, BROOKLYN, N. Y.**

Model 341
A. C. and D. C. Voltmeter

One of the Portable Electrostatic instruments. Group which also includes Model 430 Single Phase and D. C. Wattmeter, Model 429 Polyphase Wattmeter and Model 476 A. C. and D. C. Ammeter

The characteristics of the group are extreme accuracy guaranteed within a fraction of 1 per cent full-scale value, adaptability for use on circuits of any commercial frequency and any wave form, great overload capacity, low moment of inertia, effective damping and shielding and the flexibility and remarkable uniformity of the hand calibrated scales.

Working with a Single Purpose

No considerations of expediency, no motives of the moment ever have influenced the making of

Weston

Indicating Instruments

The single purpose of this Company's founder and of the Company itself has been the production of Instruments of Precision which should more and more nearly approach absolute perfection.

Weston Indicating Instruments include a great variety of groups for portable or switchboard service on A. C. or D. C. Circuits, instruments designed expressly for testing and laboratory use, for motor car and boat electrical systems, and many others for special purposes. Write for Bulletins or Catalogs describing those which interest you

Weston Electrical Instrument Co.
69 Weston Ave., Newark, N. J.

New York	Chicago	St. Louis	Montreal
Boston	Cleveland	Denver	Vancouver
Philadelphia	Cincinnati	San Francisco	London
Pittsburgh	Richmond	Toronto	Paris
Buffalo	Detroit	Winnipeg	Petrograd

GETTING HER PHIL

My Betty is a charming miss,
And all the carefuller for that.
In dancing, one's so near a kiss
My Betty is a charming miss),
She, just to keep me at a dis-
Tance, wears a sweet, but broad-
brimmed hat.
My Betty is a charming miss,
And all the carefuller for that.
Century.

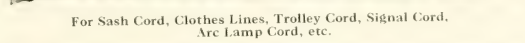
"What, kissing my daughter?"

"Well, sir, she can't talk, she can't sing, and she can't play the piano. One must do something to pass away the time."—Puck.

Him How did you like the stage hangings in that Shakespeare show?

Her There weren't no hangings, y' boob; he killed 'em with a sword. Widow.

SAMSON SPOT CORD



For Sash Cord, Clothes Lines, Trolley Cord, Signal Cord, Arc Lamp Cord, etc.

Extra Quality, guaranteed free from imperfections. Send for sample and catalogue of all kinds of braided cord.

SAMSON CORDAGE WORKS, BOSTON, MASS.

ESTABLISHED 1818

Brooks Brothers.

CLOTHING,

Gentlemen's Furnishing Goods.

MADISON AVENUE COR. FORTY-FOURTH STREET
NEW YORK

BROOKS BROTHERS' New Building Telephone Murray Hill 8800

ONLY A STEP FROM Grand Central Subway, and many leading Hotels

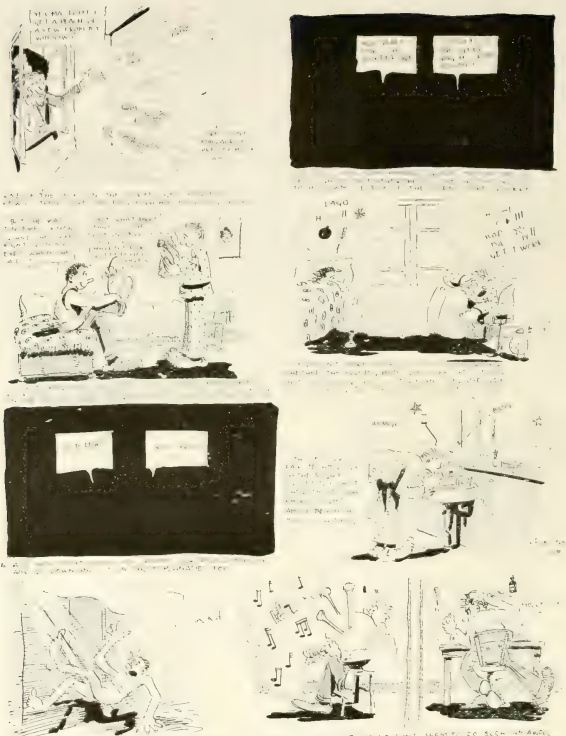
Everything for Men's and Boys' Wear in Town and Country
Clothing, Furnishings, Hats, Shoes

FOR CHRISTMAS
Ulsters, Fur and Fur-lined Coats and Jackets
Shetland Sweaters, Vests, Mufflers and Gloves
Luncheon Baskets, Thermos Cases
Fur and Wool Robes, Shawls and Mauds
Trunks, Bags and Traveling Kits

Send for "Christmas Suggestions"
an alphabetical list classified by prices

BOSTON SALES-OFFICES
149 TREMONT STREET
Eleventh Floor

DOINGS ABOUT THE INSTITUTE



ABOUT THE NEW TECH DORMS

Prof.—The boys were so entranced this morning that they remained in my lecture all through the dinner hour.

His Daughter—Why didn't you wake them up?—Princeton Tiger.

LOST IN TRANSMISSION

"Bernice is an awful prude!"

"News to me! Tell me why."

"Refused to ride with me when I told her the car's gears were stripped." Chaparral.

"Here, waiter, you've brought me two eggs, and I only ordered one."

"I know it, sir, but I didn't have the heart to separate them after all these years."

HOTEL LENOX

(Convenient to Back Bay Stations)

BOSTON

One of your College Clubs — your other home.

L. C. Prior, Managing Director

STONE & WEBSTER ENGINEERING CORPORATION

CONSTRUCTING ENGINEERS

NEW YORK BOSTON CHICAGO

TYPEWRITERS RENTED

4 Months $5.00, non visibles

3 Months $7.00, visibles

SPECIAL RATES TO STUDENTS

Initial Payment Applies if Purchased

Factory Rebuilt Typewriters $15.00 to $70.00

American Writing Machine Company

119 Franklin St., Boston 'PHONE MAIN 166

¶ THE OTHER DAY ONE OF OUR ADVERTISERS TOLD US THAT HE WAS ADVERTISING IN MANY COLLEGE PUBLICATIONS THROUGHOUT THE EAST:

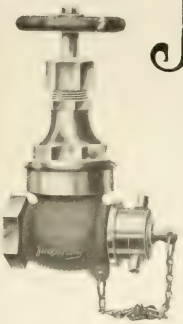
¶ **THAT THE TECHNOLOGY MONTHLY ENGINEERING JOURNAL WAS THE MOST SATISFACTORY OF THE LOT;**

¶ **THAT IT BROUGHT HIM MORE TRADE;**

¶ **THAT AS A PUBLICATION HE WOULD RATHER READ IT.**

¶ HE DID NOT MERELY MAKE THESE STATEMENTS—**HE BACKED THEM UP WITH A CHECK FOR HIS YEARLY ADVERTISING CONTRACT IN ADVANCE.** HE DID THIS BECAUSE HE, AS A SUCCESSFUL BUSINESS MAN, REALIZED THE MANY MERITS OF THE MAGAZINE.

¶ ARE **YOU** TAKING ADVANTAGE OF **YOUR** OPPORTUNITY?



Jenkins Bros. Valves

Gate Pattern, embody many features that place them practically in a class by themselves for maintained tightness under severe conditions.

Their *globe-shaped* bodies insure maximum rigidity and strength. Only the best metal and workmanship enter into the construction of every detail.

Made in three weights—standard, medium, and extra heavy, brass or iron body, and either inside screw, stationary spindle, or outside screw and yoke, rising spindle

Write for catalogue

TRADE JENKINS MARK Jenkins Bros. TRADE JENKINS MARK

80 White St., New York 523 Atlantic Avenue, Boston
13 N. 7th Street, Philadelphia 900 W. Lake Street, Chicago
Jenkins Bros. Limited, Montreal, Canada 71 London E. C. England

Hayden Costume Co.

COSTUMES FOR THE PROFESSIONAL AND AMATEUR STAGE

Plays, Operas, Carnivals, Masquerades, Etc.

243 TREMONT STREET, BOSTON, MASS.

TELEPHONE BEACH 3115

THE BARBER SHOPS AT

THE COPLEY-PLAZA Boston

THE PLAZA New York

THE GREENBRIER White Sulphur Springs, W. Va.

Are Under Management of CARL A. ZAHN

"NOT A CHANCE"

Suggestions for Tech Show Posters

TYPEWRITING MACHINES
OF ALL MAKES

Bought Sold Rented Repaired

Special Rental Rates
to Technology Students
on the Latest Models

Our machines are kept in perfect order and supplied with ribbons during the rental period

Back Bay Typewriter Exchange
334 BOYLSTON STREET, BOSTON TELEPHONE BACK BAY 3000

Technology Alumni

You are losing dividends by not joining the TECHNOLOGY BRANCH, the Co-operative store of Technology. Undergraduates and Faculty to the number of 1760, have joined. One fifth of the membership (3200) at the Harvard store are Alumni.

JOIN AND GET DIVIDENDS ON YOUR PURCHASES OF CUSTOM CLOTHING BOOKS, STATIONERY AND FURNITURE

TECHNOLOGY BRANCH

Atlantic Printing Company

Printers and Bookbinders

WE MAKE A SPECIALTY OF PUBLICATION WORK. WE CAST ALL OUR OWN JOB FACES, USING NEW TYPE FOR EACH SET-UP, WHICH INSURES GOOD, SHARP IMPRESSION

201 South Street, Boston, Mass.

'PHONE 4960 BEACH

THE TECH "CAF"

"Your Dining-Room"

Best food we can buy. Best prices you can find

BREAKFAST, 7:30—9 LUNCHEON, 11—3 DINNER, 5:30—7

THIS IS MAX

OLD CLOTHES WANTED

BY

MAX KEEZER

Highest Cash Prices Paid for Your Cast-Off Clothing

ALSO OLD GOLD, WATCHES, CHAINS, DIAMONDS, BRIC-A-BRAC, etc.

Will call at your room day or evening at your pleasure—My adv. can be found in the Technology Monthly; The Tech; Technique and Tech Show Program.

We have no agents calling at your rooms unless you telephone us.

THIS IS OUR ONLY STORE

1236 Massachusetts Avenue Cambridge

TELEPHONES: 302 / 2936 IF ONE IS BUSY CALL THE OTHER

The student of Today will be Tomorrow's engineer

It is he who must solve our country's great and growing technical problems.

So, "The Technology Monthly Engineering Journal" means something—

It is published by the students of America's greatest technology institute—

It prints important technical engineering articles by the foremost engineers of America—

It prints articles and stories of Institute and University life, and—

It pictures the happenings of the month at the Institute and the University in original cartoons by members of its staff.

It is one of the best media through which advertisers may obtain needed publicity for wares used by technical engineers. Rates on request.

Subscription $1.50 yearly

THE TECHNOLOGY MONTHLY

CAMBRIDGE, MASS.

"Old Colony Service"

AN efficient and courteous organization, progressive methods, large resources and three offices, conveniently located in different sections of Boston, combine to make the Old Colony Trust Company the most desirable depository in New England.

Interest-bearing accounts, subject to check, may be opened at any office and the three offices used interchangeably for the transaction of your banking business.

An investment department that is at all times in close contact with the bond market and financial affairs in general is at your disposal.

Modern safe deposit vaults at all offices, that offer complete protection for your valuables.

Old Colony Trust Company

52 TEMPLE PLACE 17 COURT STREET BOSTON 222 BOYLSTON ST.

ATLANTIC PRINTING CO., BOSTON